

Three new species of the genus *Ceylonosticta* Fraser, 1931 (Odonata: Zygoptera: Platystictidae) from Sri Lanka and the rediscovery of *Ceylonosticta subtropica* (Fraser, 1933)

Tharaka Sudesh Priyadarshana^{a,b*}, Ishara Harshajith Wijewardhane^{b,c} and
Bimal Eranga Herath^d

^aCollege of Forestry, Guangxi University, Nanning, Guangxi, PR China; ^bNature Explorations and Education Team, De Soysapura, Moratuwa, Sri Lanka; ^cSri Lanka School of Agriculture, Department of Agriculture, Karapincha, Kuruwita, Sri Lanka; ^dDepartment of Wildlife Conservation, National Wildlife Research and Training Center (NWRTC), Giritale, Sri Lanka

(Received 26 May 2016; final version received 2 November 2016; first published online 29 November 2016)

Three new species of *Ceylonosticta* are described and illustrated: *Ceylonosticta nancyae* sp. nov., *Ceylonosticta rupasinghe* sp. nov. and *Ceylonosticta alvisi* sp. nov. from Samanala Nature Reserve (Adam's Peak), Kuruwita-Erathna footpath, Ratnapura District, Sri Lanka. *Ceylonosticta subtropica* has been recorded for the first time after 83 years and the first depiction of its genital ligula is provided.

<http://www.zoobank.org/urn:lsid:zoobank.org:pub:0B08A725-CE88-46E5-B5F8-768736DB8062>

Keywords: *Ceylonosticta*; *Drepanosticta*; new species; Odonata; Platystictidae; Sri Lanka; dragonfly

Introduction

Sri Lanka has a rich diversity of Odonata with a high number of endemics. Fifty-two of the 125 species described so far are endemic (Bedjanič, Conniff, van der Poorten, & Salamun, 2014; Priyadarshana, Wijewardana, van der Poorten, & Jayasooriya, 2015). The family Platystictidae Laidlaw, 1924 is represented by 21 species, all of which are endemic to the island (Bedjanič et al., 2014). Members of the Platystictidae are restricted to the Oriental and Papuan regions (subfamilies Platystictinae, Protostictinae and Sinostictinae) and to Central America and northern South America (subfamily Palaemnematinae) (Dijkstra, Kalkman, Dow, Stokvis, & van Tol, 2014; van Tol, Reijnen, & Thomassen, 2009). The over 220 species are placed in seven genera: *Ceylonosticta* Fraser, 1931, *Drepanosticta* Laidlaw, 1917, *Palaemnema* Selys, 1860, *Platysticta* Selys, 1860, *Protosticta* Selys, 1885, *Sinosticta* Wilson, 1997 and *Telosticta* Dow & Orr, 2012 (Dijkstra et al., 2014; Dow & Orr, 2012; van Tol et al., 2009). Although the family is species-rich, the species are remarkably similar in general appearance (van Tol et al., 2009). Despite the small size of Sri Lanka (area: 65,610 km²), the local diversity of Platystictidae is remarkable as almost 10% of the world's species belong to the endemic genera *Ceylonosticta* and *Platysticta* of the endemic subfamily Platystictinae (Bedjanič, 2010). All 17 species of *Ceylonosticta* and

*Corresponding author. Email: tharakas.priyadarshana@gmail.com

four species of *Platysticta* are restricted to the island's wet zone and intermediate zone (Bedjanič et al., 2014). Thus, Sri Lanka is considered as a global Platystictidae hotspot (Bedjanič et al., 2014).

During recent field visits to the Samanala Nature Reserve (Adam's Peak), Kuruwita-Erathna footpath, Ratnapura district, Sabaragamuwa province of Sri Lanka, we observed some unknown species of Odonata and here we describe three new *Ceylonosticta* species based on wing venation, genital ligula, anal appendages and other morphological characteristics. Though these individuals possess the wing venation that is characteristic of both *Ceylonosticta* and *Drepanosticta*, the morphology of the genital ligula fits the description of *Ceylonosticta*. Also, we report the rediscovery of *Ceylonosticta subtropica* after 83 years (Bedjanič et al., 2014; van der Poorten & Conniff, 2012). Fraser (1933b) recorded its habitat as "Balangoda and Pettiagala, Ceylon during May and June", though it appears that Fraser himself did not collect any specimens during his 1932 trip since Kimmmins (1966) noted that the original and only known specimens (one male and one female) were collected by G.M. Henry on 21 June 1926. The new records raise the number of Odonata species recorded in Sri Lanka to 128.

Materials and methods

The authors have been documenting the diversity of Odonata around the Adam's Peak mountain region over the past two years with a special permit and grant (WL/3/2/2015) of the Department of Wildlife Conservation (DWC), Sri Lanka. The current field observations were made on 2 May 2015 and 6 June 2015 at Kuruwita-Erathna footpath (Figure 1), Ratnapura district, Sabaragamuwa Province, Sri Lanka. The area belongs to the wet zone of Sri Lanka (Ashton et al., 1997).

Live adult specimens were photographed using a Canon EOS 600D (Japan) camera body with a Canon 18–55 mm lens, and anal appendages of all the dried specimens (only male) were photographed at the laboratory with a Canon EOS 600D fitted with a 100 mm macro lens. Anal appendages and genital ligula were drafted using a light microscope (Leica DM2000, Germany). The type specimens were deposited in the research laboratory of the National Wildlife Research and Training Center (NWRTC), Giritale, Sri Lanka, under the voucher number 010TIBS–018TIBS. Leg tissues of the specimens were preserved in 100% ethanol for future molecular work. Collected samples were compared with both primary (Fraser, 1931a, 1931b, 1933a, 1933b) and secondary literature (de Fonseka, 2000; Bedjanič et al., 2014) and further comparisons were carried out with the type specimens deposited in the Natural History Museum, London, UK (NHML).

Species description

Two genera are recognized in the subfamily Platystictinae: *Ceylonosticta* and *Platysticta* (Dijkstra et al., 2014). The wing venation of *Ceylonosticta* is the same as in *Drepanosticta*. The two genera were distinguished by the presence of a dorsal ridge on the genital ligula in *Ceylonosticta* (Fraser, 1931a, 1931b). In *Ceylonosticta* and *Drepanosticta*, the sectors of the arculus are joined together for a short distance from the origin and veins IRiii and MA do not zigzag from near their origin (Fraser, 1931a, 1931b, 1933a, 1933b). In *Platysticta*, the sectors of the arculus are separated at their origin and veins IRiii and MA zigzag from near the origin (Fraser, 1931a, 1931b, 1933a, 1933b).

Ceylonosticta nancyae Priyadarshana & Wijewardana sp. nov. (Figures 2A–I, 6A–C, 7A)

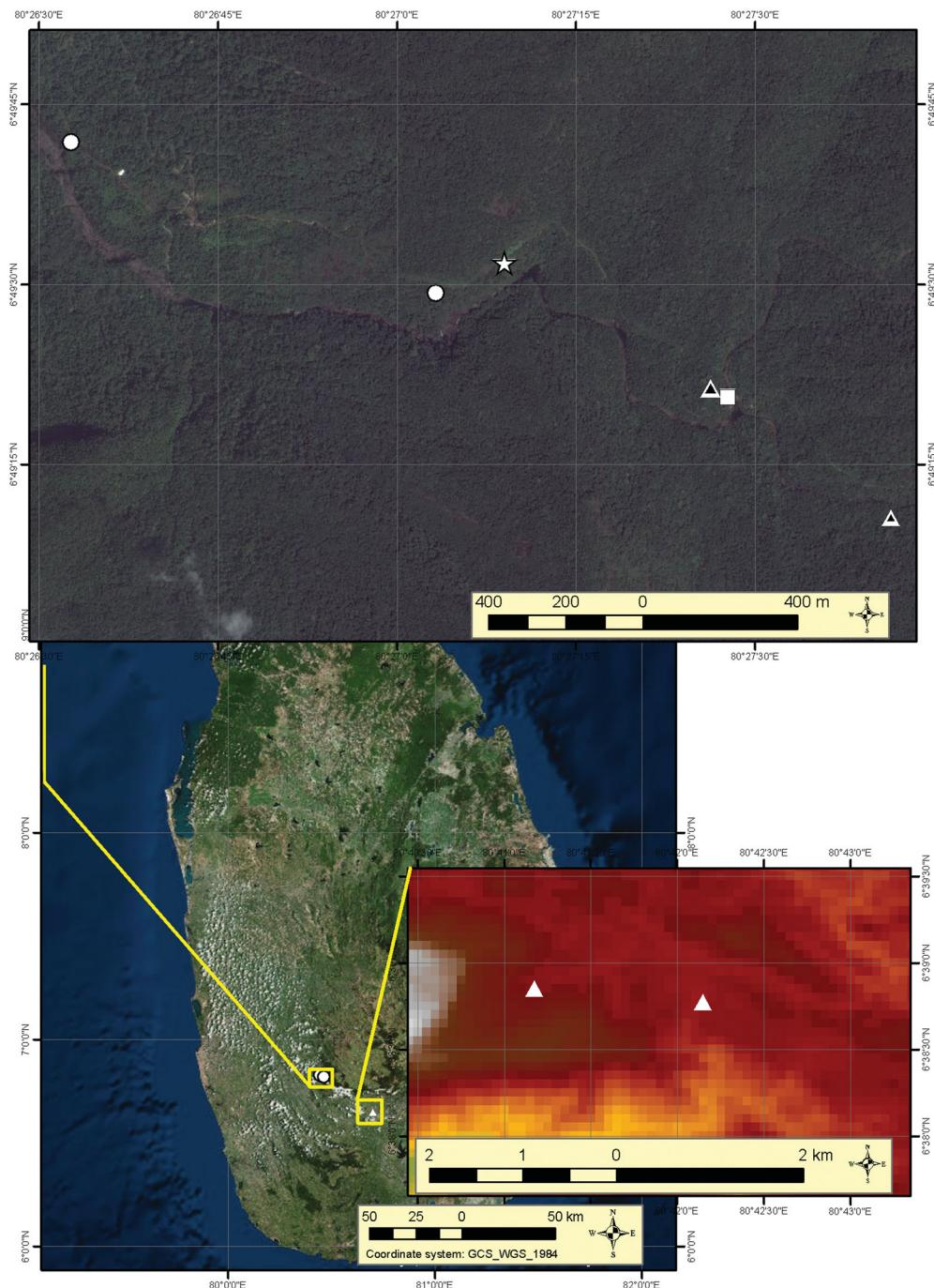


Figure 1. Localities mentioned in the text for the species: A, *Ceylonosticta nancyae* Priyadarshana & Wijewardana sp. nov., (closed circles); B, *Ceylonosticta rupasinghe* Priyadarshana & Wijewardana sp. nov., (closed square); C, *Ceylonosticta alwisi* Priyadarshana & Wijewardana sp. nov., (closed star); *Ceylonosticta subtropica* (Fraser, 1933) D, previous records (closed triangles) and E, new records (open triangles).

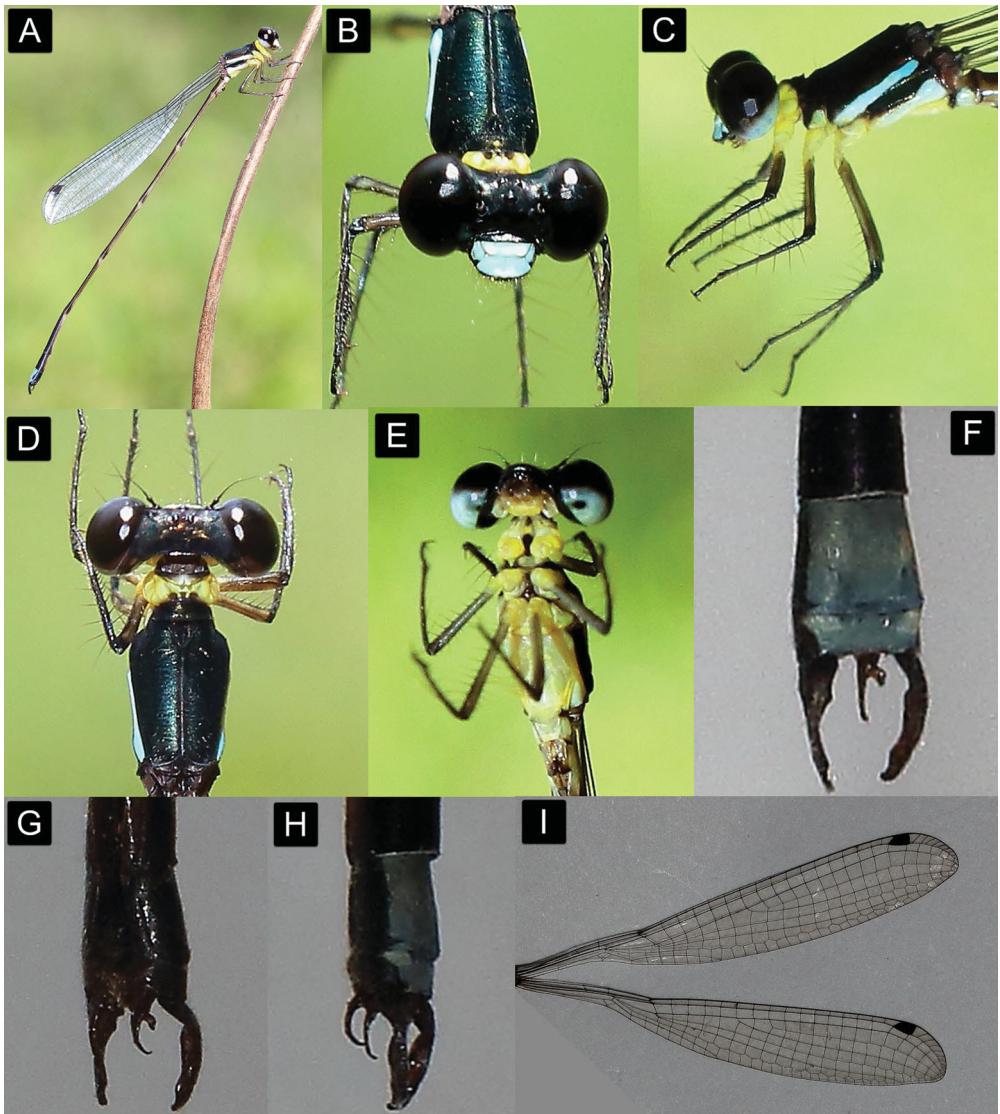


Figure 2. *Ceylonosticta nancyae* Priyadarshana & Wijewardana sp. nov., holotype (male): A, live color; B, front view; C, lateral view of prothorax and synthorax; D, dorsum of prothorax and synthorax; E, ventral view of prothorax and synthorax; F, dorsum view of anal appendages (dried specimen); G, lateral view of anal appendages (dried specimen – paratype); H, lateral view of anal appendages (dried specimen); I, wings – right pair.

Holotype. Male, 010TIBS (NWRTC), Warnagala, Adam's Peak, Ratnapura, Sri Lanka (6.8263°N, 80.4450°E, 844 m), Coll. I.H. Wijewardana, 2 May 2015.

Paratype. Male, 011TIBS (NWRTC), Warnagala, Adam's Peak, Ratnapura, Sri Lanka (6.8263°N, 80.4450°E, 844 m), Coll. T.S. Priyadarshana, 2 May 2015.

Description of holotype

Male. Head 0.4 cm, thorax 0.7 cm, abdomen 4.8 cm. **Head:** Labium brown; labrum, anteclypeus blue-white, mandible glossy black, gena blue-white in color. Frons slightly concave, metallic black below ocelli and antennae. Ocellus brown. Antennae amber-brown. Eyes deep-brown,

lower section white-blue. The rest of the head metallic black. *Prothorax*: Laterally yellowish, dorsum of anterior lobe chocolate-brown, middle lobe with a pale yellow and whitish-blue markings, and posterior lobe is metallic black. *Synthorax*: Dorsum metallic black. Mesepisternum and metepisternum black, anteriorly brown. Mesepimeron and metepimeron with whitish-blue stripes, the stripe on metepimeron broader and shorter than that on the mesepimeron and posteriorly triangular in shape. The ventral side of thorax pale yellowish with a white-blue tinge. *Legs*: Coxa and trochanter pale yellow. Femur brownish, joints darker. Tibia, tarsus and claw deep-brown. *Wings*: Hyaline. Pterostigma blackish-brown covering 1 cell. Forewing antenodals 2, postnodals $1\frac{1}{2}$; hind wing antenodals 2, postnodals $1\frac{1}{2}$. CuP reaching hind margin of forewing approximately at level of P_x4 , in hind wing at level of P_x5 . Number of cells between arculus and place where CuP meets hind margin of hind wing 8. Sectors of arculus arise from a common stalk. Ab incomplete. *Abdomen*: Slender, dorsum blackish-brown, paler ash color on lateral, ventral surface, S1 with blue-white patch on ventral surface, S2 light brown ventrally, with dark brown rings which are not connected dorsally on the base of S3–7, S8 with narrow sky-blue strip on dorsum of the distal end, S9–10 with sky-blue marking on dorsum and two black lines inward in to that blue marking on S9. *Genital ligula*: Curled over and embracing the stem of the organ which is an oval in shape. Possesses a ridge on its dorsum; the ridge is broad at base, cone-shaped and blunt at apex (Figure 6C). *Anal appendages (dried specimen)*: Both superior and inferior appendages black-brown. Superior appendages broad at the base, gradually curving inwards, spatulate at first $1/3$ and near to apex, and that spatulate portion bears a small indentation at distal end, which is more obvious in the superolateral than in the dorsal view. The superior appendages are more than twice as long as the inferior appendages. Inferior appendages broad at base and bifurcate, the shorter interior branch spreads towards the superior appendages and sharply bends downwards at the distal end, the longer exterior branch curves slightly upwards at the distal end. Apex of the inferior appendages pointed (Figure 6A, B). Paratype male did not show significant variation from the holotype; however, live coloration in paratype is brighter than the holotype.

Diagnosis. Moderately sized, almost dark brown with yellowish coloration on prothorax, similar to *Ceylonosticta anamia*, but distinguished from it by the distinct whitish-blue stripes on the mesepimeron and metepimeron, the yellowish coloration on the metinfraepisternum, coxa and trochanter. It is also distinguished from all other *Ceylonosticta* species due to the bifurcate shape of the inferior anal appendages of male (Figures 2F–H, 6A, B) in which the shorter branch sharply bends downwards at the distal end and expands towards the superior appendages while the longer branch is slightly curved upwards at the distal end.

Etymology. Species epithet (feminine singular genitive noun) is honor of Mrs Nancy van der Poorten, odonatologist and the co-author of *Dragonfly fauna of Sri Lanka: Distribution and biology, with threat status of its endemics* (2014).

Habitat and ecology. At present, *Ceylonosticta nancyae* sp. nov. is known only from the Adam's Peak, Kuruwita-Erathna footpath and its range is restricted from 6.8283°N , 80.4424°E , 729 m to 6.8248°N , 80.4509°E , 1053 m. The species has been recorded around small and shaded streams inside the forest, which is slow-moving, and small pools were observed along the streams. All the streams adjoin to the 'Kuru Ganga' (Kuru River). Both sides of the streams were densely covered with *Dicranopteris linearis*. A few individuals were observed in a slightly open area which is adjacent to the stream.

Ceylonosticta rupasinghe Priyadarshana & Wijewardana sp. nov. (Figures 3A–I, 6D–F, 7B)

Holotype. Male, 012TIBS (NWRTC), Suduwella, Adam's Peak, Ratnapura, Sri Lanka (6.8224°N , 80.4577°E , 1066 m), Coll. T.S. Priyadarshana, 6 June 2015.

Paratype. Female, 013TIBS (NWRTC), Suduwella, Adam's Peak, Ratnapura, Sri Lanka (6.8224°N , 80.4577°E , 1066 m), Coll. T.S. Priyadarshana, 6 June 2015.

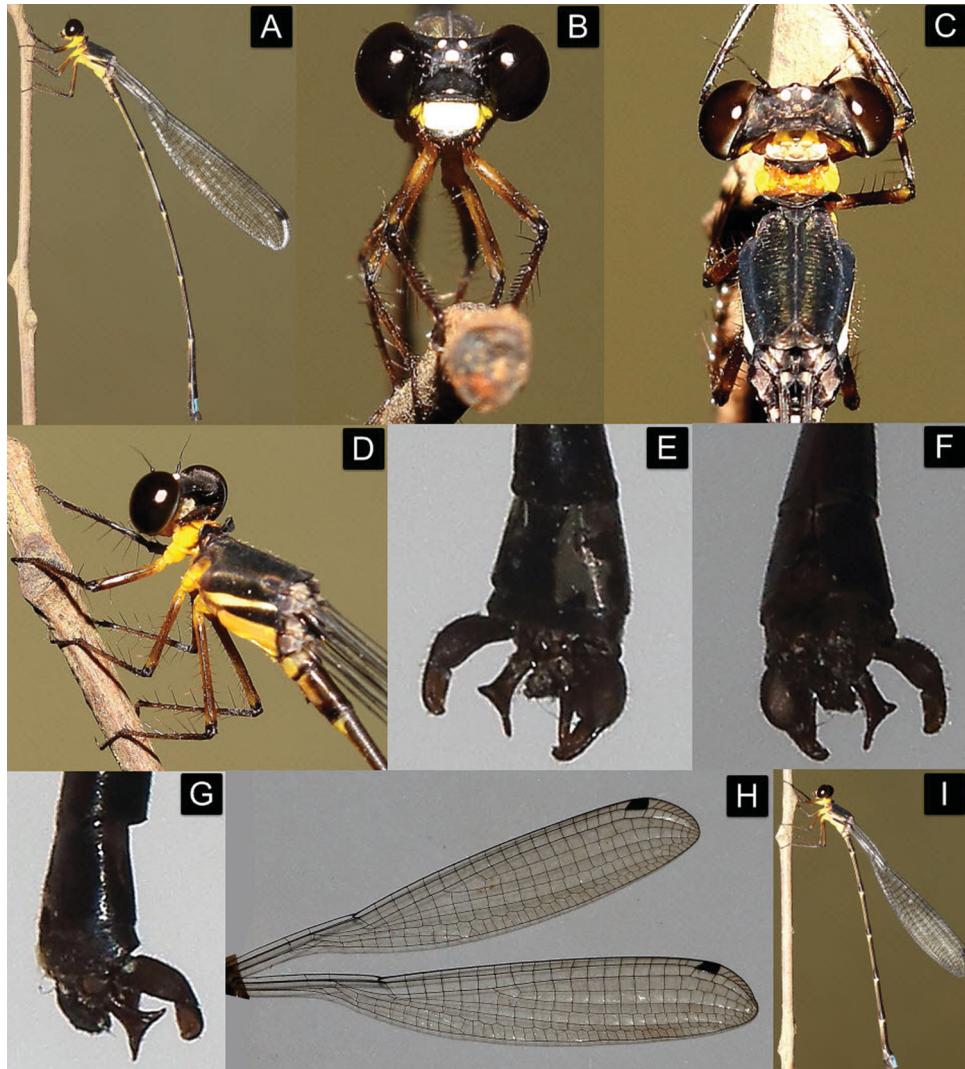


Figure 3. *Ceylonosticta rupasinghe* Priyadarshana & Wijewardana sp. nov., holotype (male); A, live color; B, front view; C, dorsum of prothorax and synthorax: prothoracic processes visible; D, dorsolateral view of prothorax and synthorax – prothoracic processes visible; E, dorsum view of anal appendages (dried specimen); F, ventral view of anal appendages (dried specimen); G, lateral view of anal appendages (dried specimen); H, wings, right pair; I, female (live color).

Description of holotype

Male. Head 0.43 cm, thorax 0.7 cm, abdomen 5.2 cm. **Head:** Labium deep-brown; labrum white-blue and bordered with glossy black, mandible glossy black, gena yellow in color, anteclypeus white-blue. Frons slightly concave, metallic black. Ocellus brown. Antennae glossy black. Eyes glossy black and narrowly border with blue-white at back edge. The rest of the head black in color. **Prothorax:** Anterior lobe white with pronounced blackish-brown posterior collar; median lobe orange-yellow; posterior lobe blackish-brown with a flattened projection on each side that it twisted at the base. In posterior lobe, it is twisted at edges. **Synthorax:** Dorsum metallic black. Mesepisternum and metepisternum black, anteriorly brown. White-blue stripe on mesepimeron, distal end pointed, and metepimeron straw colored. The ventral side of thorax straw colored.

Legs: Coxa and trochanter orange-yellow. Femur, tibia, tarsus and claw brown, joints darker. Base of the femur straw colored. **Wings:** Hyaline. Pterostigma blackish-brown covering 1 cell. Forewing antenodals 2, postnodals 17½; hind wing antenodals 2, postnodals 18½. CuP reaching hind margin of forewing approximately at level of P_{X5} , in hind wing at level of P_{X5} . Number of cells between arculus and place where CuP meets hind margin of hind wing 9. Sectors of arculus arise from a common stalk. Ab incomplete. **Abdomen:** Slender and long, dorsum blackish-brown, paler ash color on lateral, ventral surface. Segment 1 pale yellow. S2–5 with pale yellow rings ventrally at base which are not connected dorsally, S6–7 pale yellow ventrally with blue tinged rings which are not connected dorsally. S8 with dorsum of the distal end sky blue; S9–10 sky-blue dorsally. **Genital ligula:** Curled over and embracing the stem of the organ which is elliptical in shape. Possesses a ridge on its dorsum; the ridge is square in shape and slightly flat at the apex (Figure 6F). **Anal appendages (dried specimen):** black-brown. Superior appendages are broad and curve inwards, blunt at the distal end. Inferior appendages are broad at base and bifurcate, the upper branch spreads towards the superior appendages and does not bend downward at the distal end, and the lower branch curves downwards. Apices of the inferior appendages are pointed (Figure 6D, E). The superior appendages are slightly longer than the inferior appendages. **Female (paratype):** Abdomen shorter than the male, does not display significant variation with male except the anal appendages, and the dorsum of the distal end of segment 8 and segments 9–10 are sky-blue in color, blackish-brown coloration slightly inwards at the proximal end of segment 9. Anal appendages triangular in shape.

Diagnosis. Moderately sized, very colorful, almost black with orange-yellow coloration on prothorax, similar to *Ceylonosticta anamia* and *Ceylonosticta hilaris*, but distinguished from those two by having yellow coloration on the gena, a glossy black eye and a pair of lateral processes that are flattened and twisted on the posterior lobe of the prothorax (Figures 3C, D, 7B), a character not shown in any of the other *Ceylonosticta*. It is also distinguished from all other *Ceylonosticta* by of the shape of the inferior anal appendages of the male, which are bifurcate and look like an axe-head (Figures 3E–G, 6D, E).

Etymology. Species epithet (noun in apposition) is in honor of Prof. Mahinda S. Rupasinghe, geologist, and former vice-chancellor of Sabaragamuwa University, Sri Lanka.

Habitat and ecology. At present, *Ceylonosticta rupasinghe* sp. nov. is known only from the Adam's Peak, Kuruwita-Erathna footpath and has been recorded from only one location around a well-shaded small stream inside the forest (6.8224°N, 80.4577°E, 1066 m). Tree ferns and *Strobilanthes* species dominate in the vicinity. The gradient of the stream was less than 45° and water flows directly to an adjoining fairly large pool. Both holotype and paratype were observed in mating behavior. They were in the wheel position on a branch of *Strobilanthes* species at a height of 1 m from the ground, and flying speed was relatively slow.

Ceylonosticta alwisi Priyadarshana & Wijewardana sp. nov. (Figures 4A–J, 6G–I, 7C)

Holotype. Male, 014TIBS (NWRTC), Seethagangula, Adam's Peak, Ratnapura, Sri Lanka (6.8255°N, 80.4525°E, 1066 m), Coll. I.H. Wijewardana, 2 May 2015.

Paratype. Male, 015TIBS (NWRTC), Seethagangula, Adam's Peak, Ratnapura, Sri Lanka (6.8255°N, 80.4525°E, 1066 m), Coll. T.S. Priyadarshana, 2 May 2015.

Description of holotype

Male. (Holotype: head 0.3 cm, thorax 0.6 cm, abdomen 4.1 cm) **Head:** Labium brown. Labrum, mandible, anteclypeus and gena blue-white in color. Frons slightly concave, black below ocelli and antennae. Antennae black-brown. Ocellus brown. The rest of the head metallic black with brown tinge. Eyes brown, lower section barely light green with pale blue. **Prothorax:** Laterally pale yellowish, dorsum of anterior lobe chocolate-brown with a pair of long-stalked processes,

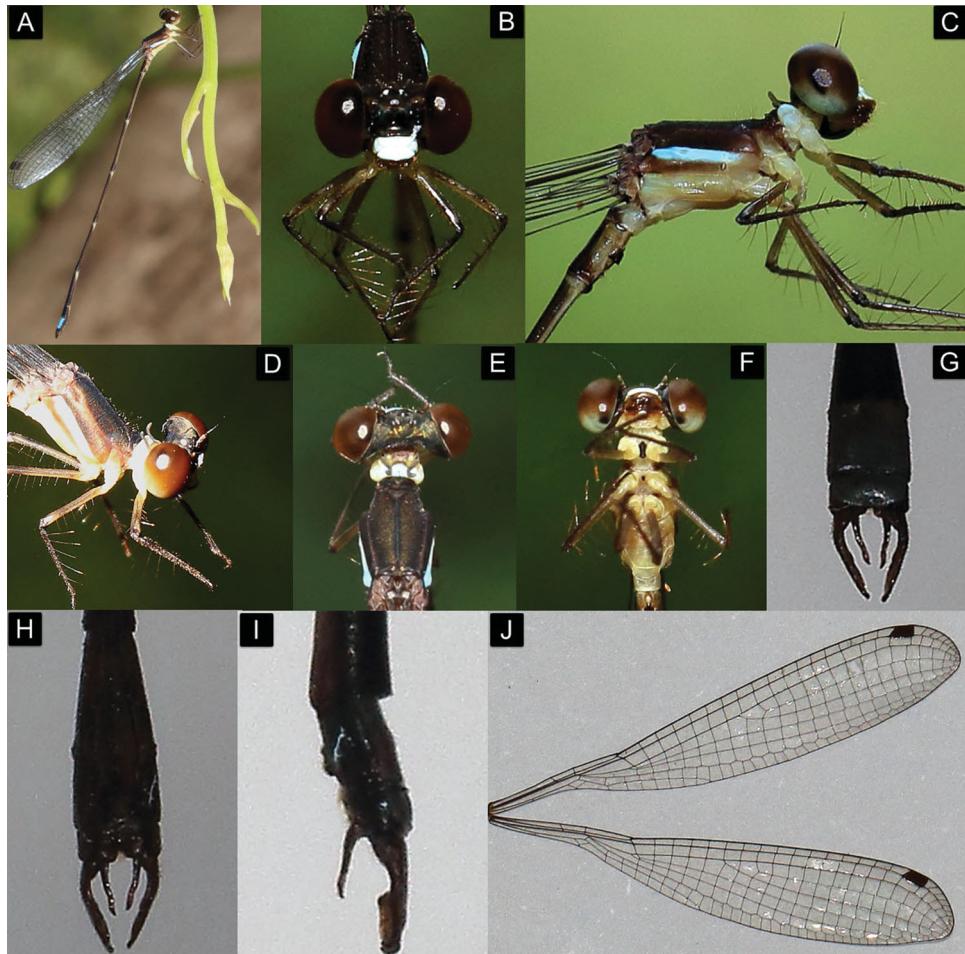


Figure 4. *Ceylonosticta alwisi* Priyadarshana & Wijewardana sp. nov., Holotype (male); A. Live color, B. Front view, C. Lateral view of prothorax and synthorax-visible prothoracic process; D. Dorsolateral view of prothorax and synthorax: prothoracic process visible; E. Dorsum of prothorax and synthorax: prothoracic process visible, F. Ventral view of prothorax and synthorax. G. Dorsum view of anal appendages (dried specimen), H. Ventral view of anal appendages (dried specimen), I. Lateral view of anal appendages (dried specimen), J. Wings, right pair.

broad at the base, curved towards the tip that incline towards the head and are cylindrical in shape. Median lobe blue-white, posterior lobe brown-black. *Synthorax*: Dorsum brown-black. Mesepisternum and metepisternum brown. Blue-white stripe on mesepimeron. Metepimeron pale yellow in color. The ventral side of thorax pale yellowish with a brown tinge. *Legs*: Coxa and trochanter pale yellow. Femur brownish, joints darker. Tibia, tarsus and claw brown. *Wings*: Hyaline. Pterostigma blackish-brown covering 1 cell. Forewing antenodals 2, postnodals 16½; hind wing antenodals 2, postnodals 15, CuP reaching hind margin of forewing approximately at level of Px5, in hind wing at level of Px5. Number of cells between arculus and place where CuP meets hind margin of hind wing 8. Sectors of arculus arise from a common stalk. Ab incomplete. *Abdomen*: Slender and long, dorsum blackish-brown, paler on lateral, ventral surface ash-colored, segment 1 and 2 glossy brown; S3–8 with pale colored rings which are not connected dorsally on the base, S8 with narrow sky-blue stripe on dorsum of distal end, and S9–10 with sky-blue marking on dorsum. *Genital ligula*: Curled over and embracing the stem of the organ which is an oval in shape. Possesses a ridge on its dorsum; the ridge is broad at

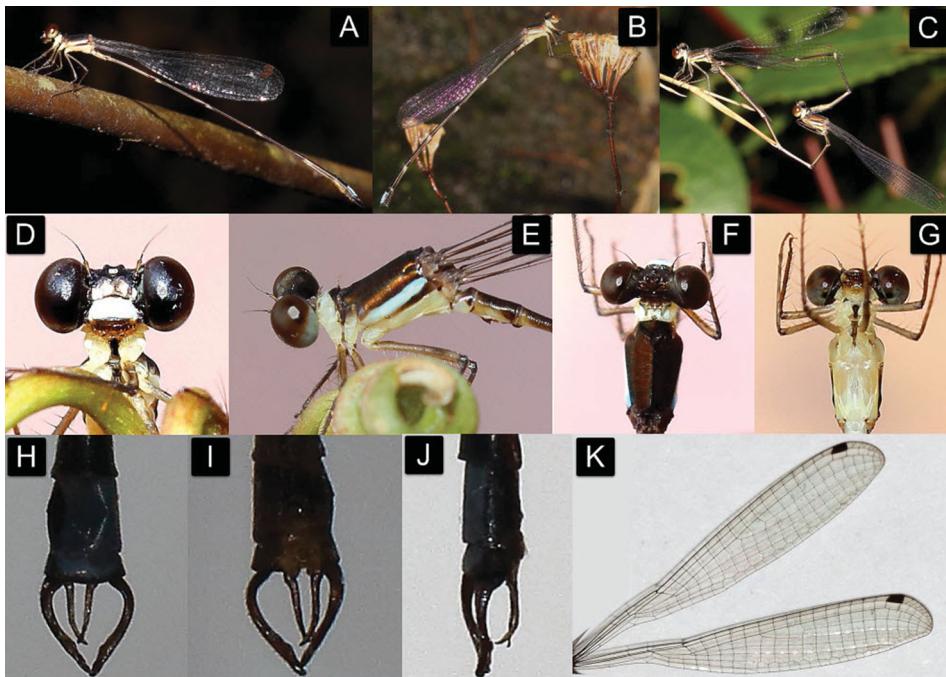


Figure 5. *Ceylonosticta subtropica* (Fraser, 1933): A, male; B, female; C, mating pair; D, front view – visible narrowly bordered glossy black labrum; E, lateral view of prothorax and synthorax – prothoracic process visible; F, dorsum of prothorax and synthorax – prothoracic process visible; G, ventral view of prothorax and synthorax; H, dorsum view of anal appendages (dried specimen); I, ventral view of anal appendages (dried specimen); J, lateral view of anal appendages (dried specimen); K, wings, right pair.

base, thumb-shaped and blunt at the apex (Figure 6I). *Anal appendages (dried specimen)*: Both superior and inferior appendages black-brown in color. Superior appendages slim, elongated and curved inwards, with a nodule at the distal end. Inferior appendages hairy and not bifurcate, approximately half the length of the superior appendage, sharply bent near the distal end, apex is pointed (Figure 6G, H).

Diagnosis. Medium sized, almost dark brown, similar to *Ceylonosticta subtropica* and *Drepanosticta* (now *Ceylonosticta*) sp. nov. A (Bedjanić et al. 2014). It can be distinguished from *C. subtropica* by the stalked clubbed processes on the anterior lobe of the prothorax that are longer than those in *C. subtropica*, and the short length and shape of the inferior anal appendages. Also, the labrum of the *C. subtropica* is narrowly bordered with glossy black (Fraser, 1933b) (Figure 5D), although the new species does not show that coloration on its labrum (Figure 4B). It also can be distinguished from *Ceylonosticta* sp. nov. A (Bedjanić et al., 2014) because in that species, the inferior anal appendages of the male are totally reduced. The new species is also easily distinguished from all the other *Ceylonosticta* by having a pair of long-stalked clubbed processes on the anterior lobe of the prothorax and the peculiar shape of the inferior anal appendages of the male. The stalked processes on the prothorax are cylindrical in shape and inclined towards the head. The inferior anal appendages are shorter than the superior appendages and sharply bend inward at the distal ¼.

Etymology. Species epithet (masculine singular genitive noun) is in honor of Mr Lyn De Alwis, founder of the Young Zoologists' Association in 1972 when he was the director of the National Zoological Garden, Dehiwala, Sri Lanka.

Habitat and ecology. At present, *Ceylonosticta alwisi* sp. nov. is known only from the Adam's Peak, Kuruwita-Erathna footpath, and has been recorded around a small stream with shade

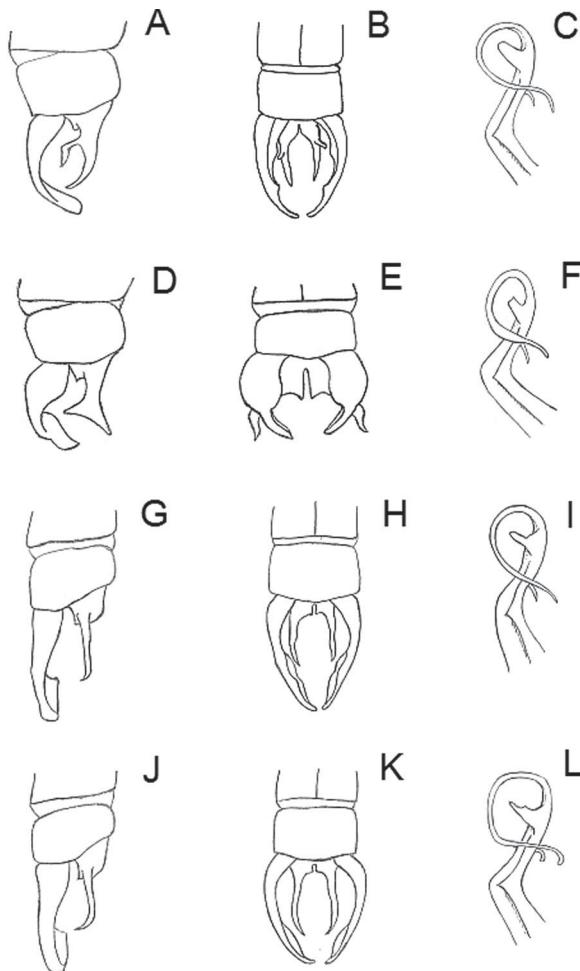


Figure 6. A–C, *Ceylonosticta nancyae* Priyadarshana & Wijewardana sp. nov., holotype (male): A, lateral view of anal appendages; B, dorsal view of anal appendages; C, genital ligula. D–F, *Ceylonosticta rupasinghe* Priyadarshana & Wijewardana sp. nov., holotype (male): D, lateral view of anal appendages; E, dorsal view of anal appendages; F, genital ligula. G–I, *Ceylonosticta alwisi* Priyadarshana & Wijewardana sp. nov., holotype (male): G, lateral view of anal appendages; H, dorsal view of anal appendages; I, genital ligula. J–L, *Ceylonosticta subtropica* Fraser, 1933: J, lateral view of anal appendages; K, dorsal view of anal appendages; L, genital ligula.

(6.8255°N , 80.4525°E , 1066 m) near the road side. Tree ferns and *Strobilanthes* species were dominant in the vicinity.

Ceylonosticta subtropica (Fraser, 1933) (Figures 5A–K, 6J–L, 7D)

Newly collected specimens. Male, 016TIBS (NWRTC), Seethagangula, Adam's Peak, Ratnapura, Sri Lanka (6.8196°N , 80.4615°E , 1109 m), Coll. I.H. Wijewardana, 6 June 2015. Male, 017TIBS (NWRTC), Suduwella, Adam's Peak, Ratnapura, Sri Lanka (6.8226°N , 80.4573°E , 1067 m), Coll. T.S. Priyadarshana, 6 June 2015. Female, 018TIBS (NWRTC), Seethagangula, Adam's Peak, Ratnapura, Sri Lanka (6.8196°N , 80.4615°E , 1109 m), Coll. T.S. Priyadarshana, 6 June 2015.

The sightings were made on 6 June 2015, around 10.30 am. The weather was initially sunny, shortly after which there was rain. We observed five males (Figure 5A), three females (Figure 5B) and one mating pair (Figure 5C). We collected two males (head 0.39 cm, thorax 0.6 cm, abdomen

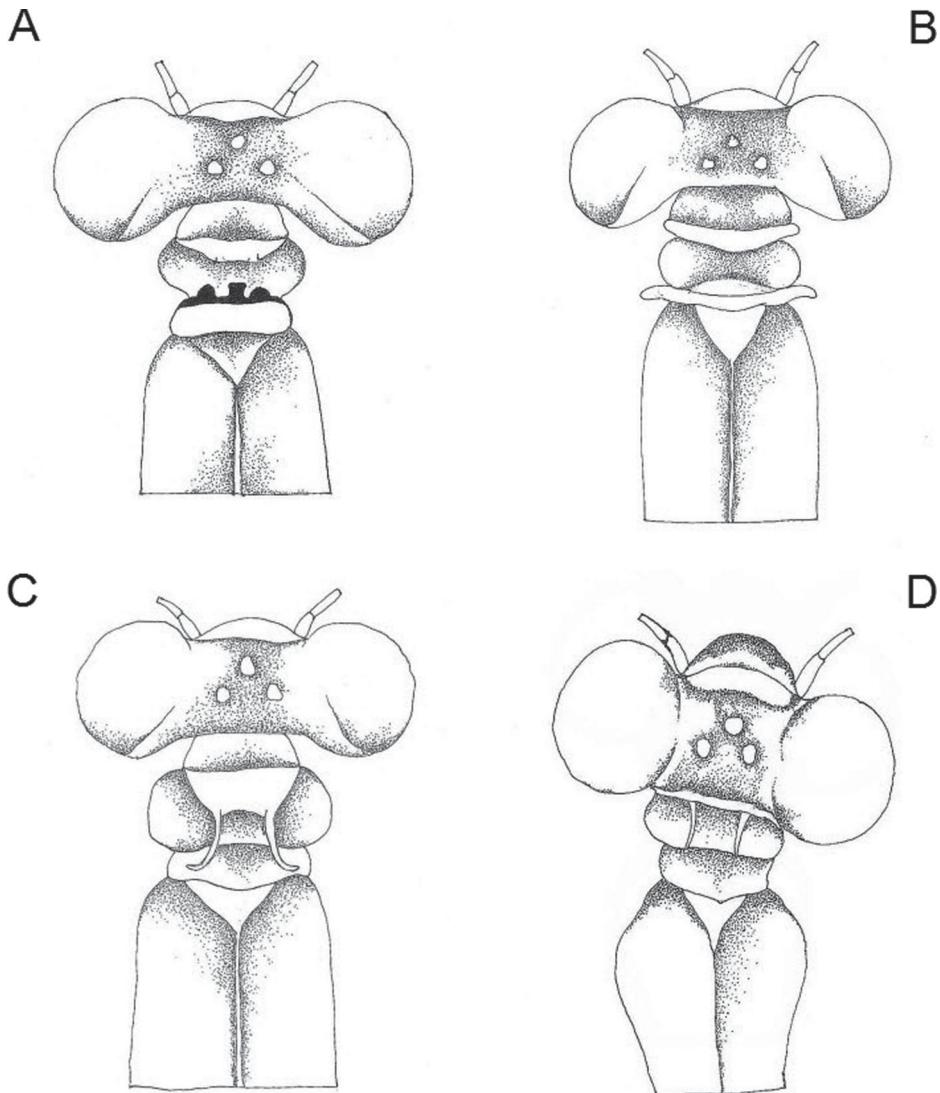


Figure 7. Thorax (holotype, male): A, *Ceylonosticta nancyae* Priyadarshana & Wijewardana sp. nov.; B, *Ceylonosticta rupasinghe* Priyadarshana & Wijewardana sp. nov.; C, *Ceylonosticta alwisi* Priyadarshana & Wijewardana sp. nov.; D, *Ceylonosticta subtropica* Fraser, 1933.

4.3 cm) and one female for further confirmation and collected specimens were deposited in the research laboratory of the National Wildlife Research and Training Center (NWRTC), Giritale, Sri Lanka. The specimens were compared with both primary (Fraser, 1933b) and secondary literature (Bedjanić et al., 2014; de Fonseka, 2000) and after careful readings we confirmed that they resembled *C. subtropica*. Further comparisons were carried out with the type specimen deposited in NHML. *C. subtropica* is characterized by the following features: the labrum is narrowly bordered with glossy black (Figure 5D), the middle lobe of the prothorax is pale blue (Figure 5E, F) and the posterior lobe is dark chocolate brown (Figure 5E, F), the apical half of the inferior anal appendages are hair-thin and it possesses a pair of yellowish-brown, long stalked processes on the anterior lobe of the prothorax (Bedjanić et al., 2014; Fraser, 1933b) (Figures 5E, F, 7D). The

genital ligula was studied for the first time (Figure 6L): it is curled over and embraces the stem of the organ which is rounded in shape; it possesses a ridge on its dorsum, it is broad at the base, sickle-shaped and pointed at the apex.

C. subtropica was observed only in the elevation range 6.8226°N, 80.4573°E, 1067 m to 6.8196°N, 80.4615°E, 1109 m, although a 6 km transect was studied. The habitat was comprised of slightly shaded small streams. *C. subtropica* is similar in appearance to *C. tropica*, *Drepanosticta* (now *Ceylonosticta*) sp. nov. A (Bedjančić et al., 2014) and *Ceylonosticta alwisi* but is distinguished from all other species of the genus on the basis of the morphology of the inferior anal appendages (Figures 5H–J, 6J, K) and other morphological characters. The inferior anal appendages are totally reduced in *Drepanosticta* (now *Ceylonosticta*) sp. nov. A which also has longer processes on the prothorax; and in the males, the last tergite of the abdomen is posteriorly prolonged (Bedjančić et al., 2014). In *Ceylonosticta alwisi*, there is a pair of long and cylindrical shaped projections on the prothorax, the inferior anal appendages are shorter than in *C. subtropica* and the length of the sharply bent distal end is very short. *C. tropica* has a reddish-brown prothorax, the labrum is not bordered with black and the inferior anal appendages are more robust and not thin at the apical end (Fraser, 1933b).

Note. As mentioned above, Fraser's (1933b) descriptions of *C. subtropica* (anal morphology, thoracic morphology and labrum coloration) fit with the new samples that we have collected from Samanala Nature Reserve (Adam's Peak), Ratnapura district, Sri Lanka. According to the description of the anal appendages of *C. subtropica* in Fraser (1933b), the “inferiors [are] about three quarters the length of superiors”. However, that description does not match with his drawings, in which the inferiors are shown as approximately two-thirds of the length of the superiors. In the type specimens of *C. subtropica* which are deposited in NHML, the inferiors show as two-thirds of the superiors. The newly collected specimens from Adam's Peak, Sri Lanka also have inferiors that are two-thirds of the superiors, agreeing with both Fraser's original descriptions and the type specimen at the NHML. Therefore, this coherency of multiple criteria led us to confirm the re-discovery of *C. subtropica*.

Discussion

Since phylogenetic studies have shown that the Oriental subfamily Platystictinae is paraphyletic, it has been limited to the species found in Sri Lanka (*Ceylonosticta* and *Platysticta*) and a new subfamily, Protostictinae, was erected for the rest of Asian Platystictidae (Dijkstra et al., 2014). Though wing venation has traditionally played a key role in odonate taxonomy, recent phylogenetic studies have proved that wing venation is not always a reliable indicator of the relationships in the Odonata since similar characters may have evolved multiple times (Dijkstra et al., 2014; Suhling, Sahlén, Gorb, Kalkman, Dijkstra, & van Tol, 2015). That is being overcome by considering multivariate morphological features of the adults as well as larval characters (Fleck, Brenk, & Misof, 2008; Rehn, 2003; von Ellenrieder, 2002).

The genus *Ceylonosticta* was erected by Fraser (1931a, 1931b) for the species found in Sri Lanka based on a single character: a dorsal ridge on the genital ligula. This feature is shared by *Platysticta* which is distinguished from *Ceylonosticta* by the wing venation. Fraser (1931a) illustrated the genital ligula for *Drepanosticta*, *Ceylonosticta*, *Protosticta* and *Platysticta*. The genus *Ceylonosticta* originally included the following species: *C. adami*, *C. digna*, *C. hilaris* (the genotype), *C. lankanensis*, *C. nietneri*, *C. montana*, *C. tropica*, *C. subtropica*, *C. submontana* and *C. walli* (Fraser, 1931a, 1931b, 1933a, 1933b). Later authors, however, considered them to be members of the genus *Drepanosticta*. Lieftinck (1940) listed *Drepanosticta digna* and described a new species *D. austeni*, but did not explain why he did not use the genus name *Ceylonosticta*, nor did he mention whether or not the genital ligula was examined. Lieftinck (1955) described

Drepanosticta fraseri (now considered a synonym of *C. submontana* (Bedjanč, 2012) and wrote that: “this new species is a *Ceylonosticta* Fraser, a genus which I am unable to differentiate from *Drepanosticta* Laidlaw, and which I therefore consider synonymous with the latter”, but again did not indicate whether the genital ligula was examined. The genus name *Ceylonosticta* was reinstated for the species in Sri Lanka following a phylogenetic study that included only the following species: *C. nietneri*, *C. montana*, *C. walli*, and *C. austeni* (Dijkstra et al., 2014). The first three species were included in Fraser’s original definition of the genus *Ceylonosticta* and were presumably examined for the presence of the ridge on the genital ligula. The character of the genital ligula of *C. austeni* has not been published.

In this article, we have illustrated the genital ligula of *C. subtropica*, as well as of the three new species. Thus, this study emphasizes that it is necessary to illustrate the genital ligula of the remaining species of the genus: *C. anamia*, *C. bine*, *C. brincki*, *C. mojca*, *Drepanosticta* (now *Ceylonosticta*) sp. nov. A and B, which may help to resolve taxonomic issues. We also suggest examining the phylogenetic relationships and their higher-level relationships within the genus *Ceylonosticta* and evaluating the conservation status of the species to inform and initiate conservation strategies.

All 21 species of Platystictidae in Sri Lanka are restricted to habitats of the wet and intermediate zones in the southwestern and central parts of Sri Lanka and all species are limited to an area of approximately 20,000 km² (Bedjanč et al., 2014). The larvae of Platystictidae species typically live between plant debris in small streams and seepages in deep shade while the adults are found perched on branches or on the tips of leaves or twigs in such sites (van Tol et al., 2009). Such sites are particularly important to tropical ecosystems, where levels of endemism tend to be higher than in more temperate regions and, consequently, the risks of species becoming globally extinct may be greater. However, these habitats are under preternatural anthropogenic pressure due to higher demand for agricultural lands and human settlements. At present, only a fraction of the former range of the Sri Lankan wet and intermediate zone forests remain and thus many species of Odonata have lost most of their habitats or have highly fragmented habitats. The heavy use of chemical pesticides and herbicides are also a major concern because of the dependency of odonates on clean water sources for the development of the larval stages (van der Poorten & Conniff, 2012). Thus, immediate conservation measures are necessary as most Platystictidae species are threatened according to IUCN criteria.

After this manuscript was accepted for publication, the monograph “Taxonomy and molecular phylogeny of the Platystictidae of Sri Lanka (Insecta: Odonata) by Bedjanč, M., Conniff, K., Dow, R. A., Stokvis, F. R., Verovnik, R., & Tol, J. V. (2016). *Zootaxa*, 4182, 1–80. doi:10.11646/zootaxa.4182.1.1” was published. Though this monograph provides much new information, it does not affect the main thesis of this article.

Acknowledgements

This project was funded by the Department of Wildlife Conservation (DWC), Sri Lanka [grant number WL/3/2/2015]. The authors thank: Nancy van der Poorten for advice, literature, and several critical reviews of the manuscript; Department of Wildlife Conservation (DWC), Sri Lanka and National Wildlife Research and Training Center (NWRTC), Giritale, Sri Lanka for issuing the necessary permit for this study; Benjamin W. Price of the Natural History Museum, London for help with specimens; Sadarwan Hettiarachchi, Aravinda Bhoomi and Chamara Amarasinghe for camera apparatus; Yohan Buddika (Sabaragamuwa University, Sri Lanka) for mapping; Indika Peabotuwage (Guangxi University, People’s Republic of China) for drawings; and George van der Poorten, Madhava Meegaskumbura (Peradeniya University, Sri Lanka), Eben Goodale (Guangxi University, People’s Republic of China), Sandun J. Perera (Sabaragamuwa University, Sri Lanka), Uromi Manage Goodale (Guangxi University, People’s Republic of China), Sameera Karunaratne (Nature Explorations and Education Team, Sri Lanka), Kanishka Ukuwela (Rajarata University, Sri Lanka), Nayana Wijayathilaka (The Open University, Sri Jayewardenepura Kotte, Sri Lanka), Gayani Senevirathne (The University of Chicago, United States), Thasus Amarasinghe (University of Indonesia), Suresh Wenuka Godakanda (Sabaragamuwa University, Sri Lanka), He Ruchuan (Guangxi University, People’s Republic of China) and Leena Priya Segaran (National University of Singapore) for their support and encouragement on this study. We also thank

Klaas-Douwe B. Dijkstra (University of Stellenbosch, South Africa), Matjaž Bedjanič (Slovenia) and John C. Abbott (The University of Alabama, USA) for commenting on the first manuscript.

Funding

This work was supported by Department of Wildlife Conservation (DWC), Sri Lanka [grant number WL/3/2/2015].

References

- Ashton, M., Gunatilleke C. V. S., de Zoysa, N., Dassanayake, M. D., Gunatilleke, N., & Wijesundara, S. (1997). *A field guide to the common trees and shrubs of Sri Lanka*. Colombo: Wildlife Heritage Trust of Sri Lanka. Retrieved from <http://static1.1.sqspcdn.com/static/f/1199264/19112099/1341476244047/-Trees%2B%2BShrubs.pdf?3Ftoken%3DCMLdjGZkMGsJ0BYy7RrA9bVa5Mc%253D>
- Bedjanič, M. (2010). Three new *Drepanosticta* species from Sri Lanka (Zygoptera: Platystictidae). *Odonatologica*, 39, 195–215. Retrieved from <http://natuurjdschriften.nl/download?type=document;docid=592699>
- Bedjanič, M. (2012). On the synonymy of three endemic dragonfly species from Sri Lanka (Zygoptera: Platystictidae, Protoneuridae). *Notulae odonatologicae*, 7, 77–88.
- Bedjanič, M., Conniff, K., van der Poorten, N., & Salamun, A. (2014). *Dragonfly fauna of Sri Lanka: Distribution and biology, with threat status of its endemics*. Sofia: Pensoft.
- de Fonseka, T. (2000). *The Dragonflies of Sri Lanka*. Colombo: Wildlife Heritage Trust. Retrieved from <http://www.wht.lk/all/single-gallery/15477026>
- Dijkstra, K. D. B., Kalkman, V. J., Dow, R. A., Stokvis, F. R., & van Tol, J. (2014). Redefining the damselfly families: a comprehensive molecular phylogeny of Zygoptera (Odonata). *Systematic Entomology*, 39, 68–96. doi:10.1111/syen.12035
- Dow, R. A., & Orr, A. G. (2012). *Telosticta*, a new damselfly genus from Borneo and Palawan (Odonata: Zygoptera: Platystictidae). *The Raffles Bulletin of Zoology*, 60, 365–401. Retrieved from [https://www.researchgate.net/profile/Albert_Orr/publication/263442881_Telosticta_a_new_damselfly_genus_from_Borneo_and_Palawan_\(Odonata_Zygoptera_Platystictidae\)/links/0a85e53ad6c20a6ffa000000.pdf](https://www.researchgate.net/profile/Albert_Orr/publication/263442881_Telosticta_a_new_damselfly_genus_from_Borneo_and_Palawan_(Odonata_Zygoptera_Platystictidae)/links/0a85e53ad6c20a6ffa000000.pdf)
- Fleck, G., Brenk, M., & Misof, B. (2008). Larval and molecular characters help to solve phylogenetic puzzles in the highly diverse dragonfly family Libellulidae (Insecta: Odonata: Anisoptera): the Tetraphemistinae are a polyphyletic group. *Organisms Diversity & Evolution*, 8 (1): 1–16. doi:10.1016/jоде.2006.08.003
- Fraser, F.C. (1931a). Indian dragonflies (part 37). *Journal of the Bombay Natural History Society*, 35, 66–99. Retrieved from <http://www.biodiversitylibrary.org/part/202302>
- Fraser, F.C. (1931b). Indian dragonflies (part 38). *Journal of the Bombay Natural History Society*, 35, 325–341. Retrieved from <http://www.biodiversitylibrary.org/part/202303>
- Fraser, F. C. (1933a). *The fauna of British India including Burma and Ceylon, Odonata* (Vol. 1). London: Taylor and Francis. Retrieved from <https://archive.org/details/FraserOdonata1>
- Fraser, F. C. (1933b). The Platystictas of Ceylon (Order Odonata). *Ceylon Journal of Science: Biological Sciences*, 17, 201–224.
- Kimmins, D. E. (1966). A list of Odonata types described by F.C. Fraser, now in the British Museum (Natural History). *Bulletin of the Natural History Museum. Entomology*, 18, 173–227. Retrieved from <http://www.biodiversitylibrary.org/item/19523#page/261/mode/1up>
- Lieftinck, M. A. (1940). On some Odonata collected in Ceylon, with descriptions of new species and larvae. *Ceylon Journal of Science: Biological Sciences (B)*, 22, 79–91.
- Lieftinck, M. A. (1955). Synopsis of the dragonflies (Odonata) of Ceylon. *Zoologische Mededelingen*, 34, 69–73. Retrieved from <http://dare.uva.nl/cgi/arno/show.cgi?fid=149975>
- Priyadarshana, T. M. T. S., Wijewardana, G. V. I. H., van der Poorten, N., & Jayasooriya, A. L. A. C. (2015). First record of *Gynacantha millardi* (Odonata: Aeshnidae) from Sri Lanka. *Taprobanica*, 7, 266–267.
- Rehn, A. C. (2003). Phylogenetic analysis of higher-level relationships of Odonata. *Systematic Entomology*, 28, 181–240. doi:10.1046/j.1365-3113.2003.00210.x
- Suhling, F., Sahlén, G., Gorb, S., Kalkman, V. J., Dijkstra, K. D. B., & van Tol, J. (2015). Order Odonata. In: J. H. Thorp, & D. C. Rogers (Eds.), *Ecology and general biology: Thorp and Covich's freshwater invertebrates* (pp. 893–932). Amsterdam: Academic Press. doi:10.1016/b978-0-12-385026-3.00035-8
- van der Poorten, N., & Conniff, K. (2012). The taxonomy and conservation status of the dragonfly fauna (Insecta: Odonata) of Sri Lanka. In D. K. Weerakoon, & S. Wijesundara (Eds.), *The National Red List 2012 of Sri Lanka: Conservation status of the fauna and flora* (pp. 1–10). Colombo, Sri Lanka: Ministry of Environment. Retrieved from <http://www.ceal.lk/web/images/pdf/redlist2012.pdf>
- van Tol, J., Reijnen, B. T., & Thomassen, H. A. (2009). Phylogeny and biogeography of the Platystictidae (Odonata) (Post-doctoral dissertation). Institute Biology Leiden, Faculty of Science, Leiden University. Retrieved from <https://openaccess.leidenuniv.nl/handle/1887/13522>
- von Ellenrieder, N. (2002). A phylogenetic analysis of the extant Aeshnidae (Odonata: Anisoptera). *Systematic Entomology*, 27, 437–467. doi:10.1046/j.1365-3113.2002.00190.x